Office of Technical Assistance Research Proposal

Gas Phase Dyeing and Coloring of Textile Yarn and Fabric

Abstract

Since most synthetic and natural polymers are permeable to gas, it is suggested that dye and/or coloring of yarn and fabric could be achieved by using dyes in the gas phase. Essentially we are suggesting two different approaches 1) altering the polymer structure of the fiber to change color upon exposure to some kind of gas 2) creating dyes in a gas phase that could permeate existing polymer structures and impart color.

Colored wastewater from textile and paper mills is becoming an increasing problem for the quality of our natural waters. . Further, the EPA and the Commonwealth of Massachusetts are currently working on a statute to establish a color parameter for dischargers to public waters. This would severely limit the operations or many textile and paper mills particularly the older marginally profitable mills.

Background

Currently natural and synthetic yarns and fabrics are colored using aqueous processes involving dilute solutions of dyes, chemicals and large volumes of water to “carry” the dyes into the yarn. Direct dyes are by far the single most popular type of dye because they are very economical and can be applied to most popular natural fibers such as cotton and cellulosics. Disperse dyes would also represent a significant portion of synthetic dye production because they are the only dyes which can be used to dye conventional homopolymer polyester. The dye process is substantive i.e. the dye is removed from the solution by the substrate, thereby depleting the dye from the solution. Therefore in order to obtain a certain color or shade, the substrate must absorb a certain amount of dye. This amount is somewhat predictable given the nature and weight of substrate, however, it precludes predetermining the exact amount of dye required. Therefore, in order to get a predetermine color, the process must be charged with an excess of dye and/or the process run until the color is achieved. Most often these conditions are fairly well predicted but this does not preempt finishing the dye batch with an excess of unused color in the spent bath.

Scope of Problem

Although the textile industry has invested substantial resources into developing systems for reclaiming the unused dyes and water, no economically attractive system has been developed to date. As a result, colored wastewater must be discharged to an onsite pretreatment process before the discharge to the local POTW or a local body of surface water. Most often, neither the onsite pretreatment process the local POTW can remove all of the color and therefore the receiving body of water becomes discolored by the spent dye solution. We know of on Massachusetts company that discharges 3 million gallons/day of

wastewater from its various dye processes. When they are discharging large quantities of off colors such as red or orange, they must call the local POTW and warn them of the occurrence.
The POTW can't do anything about this but at least they can identify the source of the color. There are 11 textile finishing plants (SIC 2261 – 2269), 12 coated fabrics plants (SIC 2295 – Not Rubberized) and 6 fabric mills in the Commonwealth that discharge a total of about 20 million GPD of waste water to public water bodies either directly to a stream or indirectly to a POTW. There are 12 paper mills (SIC 2621), 3 paperboard mills (SIC 2631), 7 corrugated and solid fiber boxes, 13 coated and laminated packaging paper mills and other facilities using water in large quantities to make specialized paper products. Further, the EPA and the Commonwealth of Massachusetts are currently working on a statute to establish a color parameter for dischargers to public waters. This would severely limit the operations or many textile and paper mills.

Objectives
There is no shortage of alternative technology available for dyeing and finishing textiles. However, our search did not uncover a process that applied colors or chemically alters the color of fabric or yarn from a gaseous phase. It would seem that fibers could absorb a gas carrying the dye or a dye in a gas phase via processes similar to ion implantation, gas plasma surface alteration or vacuum metaliztion.
Several methods of achieving this would be:
1 Searching for reactive dyes that have subliminal properties, which are activated by vacuum and/or temperature

2 Search for materials that can be grafted on synthetic polymers prior to the fiber spinning process that would act as chromophors upon exposure to certain gases.

3 Search for disperse dyes that occur in gaseous phase that would permeate and color natural and synthetic fibers.

Some of these materials might loan themselves to be applied in a plasma phase however they would have to be very potent in order to achieve any degree of coloration at the gas concentrations common with plasma.

A cursory search of patent literature on this subject uncovered several patents that allude to or simulate this concept. There is a patent that covers dyeing of fabrics with a CO_2 solution of dyes. Other patents describe processes that use specially formulated dyes that are fixed with UV light or EBEAM energy.

OTA can assist in the identification of an industry partner for this project.